CONTROL OF THE ROOT, STALK, AND EAR ROT DISEASES OF CORN

JAMES R. HOLBERT
Pathologist, Office of Cereal Investigations
and
GEORGE N. HOFFER
Associate in Botany, Indiana Agricultural Experiment Station, and Pathologist and Agent, Office of Cereal Investigations

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Reading the Results at the Completion of the Seed-Corn Germination Test

FARMERS' BULLETIN 1176
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

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THE corn crop in 1919 was worth more than all other cereal crops combined.

The rot diseases of the roots, stalks, and ears of corn are widely distributed in this country wherever corn is grown.

They cause heavy losses, particularly in the corn belt. The loss in 1919 is estimated at 125,175,000 bushels, or 4 per cent of the total crop.

These diseases are caused by several organisms and probably by some other contributing factors.

They may be recognized in germination tests and in the fields by certain symptoms and may be largely controlled by the methods described herein.

Select well-matured seed at the proper time from healthy plants. Avoid all leaning or broken plants and all broken ear shanks even if the ears look healthy.

Select about five times as many seed ears as will be needed, to allow for discarding later all ears found to be diseased.

Cure and store the seed ears in a dry, well-ventilated place. Full directions are given in Farmers' Bulletin 1175.

After the seed ears are thoroughly dry, discard all ears with denting that is too rough or with pink, discolored, cracked, or shredded shank attachments, or with moldy, discolored, or starchy kernels.

Make a special germination test of ten representative kernels from each seed ear selected.

Keep for seed only those ears represented on the germinator by ten healthy seedlings, cutting open the ten kernels to make sure they are not rotted, even if the sprout appears to be healthy.

Discard butt and tip kernels. Then shell each ear separately by hand.

In shelling, discard any ears with kernels that are starchy, moldy, or dull in color.

CONTROL OF THE ROOT, STALK, AND EAR ROT DISEASES OF CORN.[1]

JAMES R. HOLBERT,
Pathologist, Office of Cereal Investigations, and
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Associate in Botany, Indiana Agricultural Experiment Station, and Pathologist and Agent, Office of Cereal Investigations.

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IMPORTANCE OF CORN.

CORN is the most important field crop in the United States. Its value is greater than the combined values of wheat, oats, barley, rye, rice, grain sorghums, and buckwheat. Among the cereals it is a "highly productive crop, yielding on the average about twice as much grain, and, including the fodder, over three times as much food per acre as either wheat or oats." On its production depends, to a large extent, our enormous beef and pork industry.

The commercial varieties include dent corn, flint corn, sweet corn, flour corn, and pop corn. While all of these different kinds of corn have been found to be susceptible to rot diseases of the roots and stalks, the statements in this bulletin apply chiefly to the dent varieties grown in the corn belt.

LOSSES CAUSED BY THESE DISEASES.

The rot diseases of the roots, stalks, and ears of corn cause great losses, are widely distributed, have distinct characteristics, and require special control measures.

[1] The investigations on which this bulletin is based were conducted in cooperation with the Department of Botany, Indiana Agricultural Experiment Station, and Funk Brothers Seed Company, of Bloomington, Ill. The destructiveness of these diseases and the necessity of preventing their spread through seed corn was brought to the attention of the Department by Mr. Eugene D. Funk, who had initiated the investigation in Illinois upon his own farms.

The most careful estimates possible indicate that these diseases cause greater losses in this country than any others affecting corn. In fact, it is believed that they cause greater damage than all the other corn diseases, smut, rust, brown-spot, etc., combined. The losses in 1919 were conservatively estimated at 125,175,000 bushels, or 4 per cent of the total crop.

The actual losses caused by these rots in the corn-belt States can not be accurately estimated. If it were possible to determine the losses caused by poor stands resulting from planting infected seed and also the losses due to the stunting of the growth of the many remaining plants, with the consequent reduced size of ears, it is believed that the total would be fully 10 per cent and perhaps more.

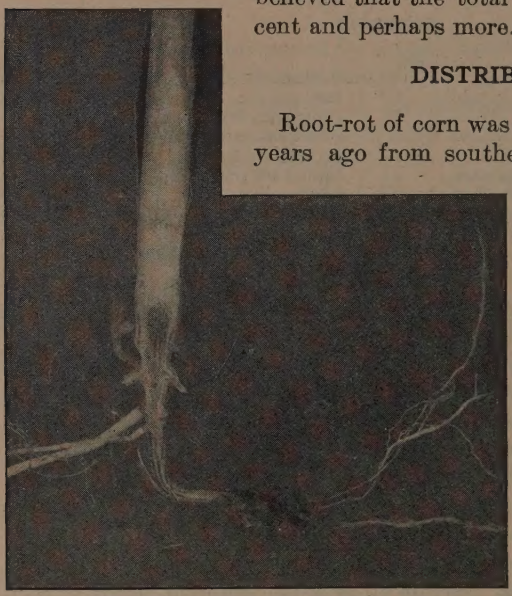

FIG. 1.—Diseased corn seedling, showing blackened roots and kernel and discolored inner tissues of stem.

DISTRIBUTION.

Root-rot of corn was first reported about 15 years ago from southern Ohio, where it was causing marked losses. Later it was reported from Iowa, Nebraska, Illinois, Missouri, and Minnesota. During the last two years (1918–19) it has been found in all of the corn-growing States.

While these diseases have been found to some extent practically wherever corn is grown in this country, they seem to be most destructive in the corn belt. It is in this section that the most extensive investigations have been carried on, particularly in Illinois and Indiana, and it is to this section that statements in this bulletin are most directly applicable.

In the Southern States the frequent return of corn to the same field in the rotation, and the less common use of the germination test both tend to make the disease abundant.

These rot diseases cause the heaviest losses in dent corn, because this is the commercial corn crop of this country. Sweet corn and flour corn, however, seem to be more severely affected. Not so much disease has been found in flint corn or pop corn where these are commercially grown, this being due, perhaps, in part to less favorable climatic conditions.

CAUSES OF THE ROT DISEASES.

These rot diseases are caused by a number of factors working more or less together, some of which are well known and others less fully known. Investigations have shown that certain fungi,[2] as well as certain bacteria are commonly present in diseased corn plants in the fields. On the germinator these organisms, as well as certain molds (Rhizopus, Aspergillus, etc.), also may occur on diseased, weak, or immature kernels and seedlings. These various organisms and other factors are being investigated further in order to learn more definitely the part each plays in causing these diseases.

Sometimes the injuries may be confined to the roots only, but in other cases the same organisms affect the stalks and ears as well. Frequently the injuries to the ears are only very slight. Herein lies much of the difficulty in selecting seed corn, as unless special precautions are taken these infected ears will be used for seed.

FIG. 2.—Diseased corn seedlings, 11 days old, showing infections of varying severity: *A*, Dead: *B*, dying; *C*, moderately diseased, yellowish, and stunted, which may make slow growth and prove barren.

The structure of the corn plant is such that the early rotting of the stalk can not be readily observed. The organisms usually enter the base of the stalk while the plant is young and tender. The softer inner tissues are the ones which are first affected, discolored, and disorganized. The hard outer tissues of the stalk prevent the rots from developing rapidly through them, and for this reason the changes in the outward appearance of the infected stalks are not very marked at first.

One of the most striking discoveries in this investigation of corn rots is the fact that one of the fungi already mentioned[3] is the same fungus that is most commonly the cause of wheat blight or scab. It develops abundantly on old corn stalks and is the most important source of scab infection when wheat follows diseased corn in the rotation.

[2] Particularly *Gibberella acervalis* (Moug.) Wr. and *Gibberella saubinetii* (Mont.) Sacc. (the latter the cause of wheat scab).

[3] *Gibberella saubinetii.*

DESCRIPTION OF THE ROT DISEASES.

The diseases herein described may attack the plant at any stage in its development from the seedling stage to maturity. They produce certain fairly well marked effects (symptoms) that may be recognized in the different stages of growth of the plant. For convenience, the development period of the plant is divided into four parts, namely, the seedling stage, the young-plant stage, the silk-and-tassel stage, and the ear stage.

SYMPTOMS SHOWN IN THE SEEDLING STAGE.

When kernels of corn which are infected by the rot organisms are planted, the conditions in the soil which favor the germination of the seed and the growth of the young seedling also favor the growth and development of the organisms. These organisms may spread directly from the planted kernel into the tissues of the young seedling or through the soil to the growing roots.

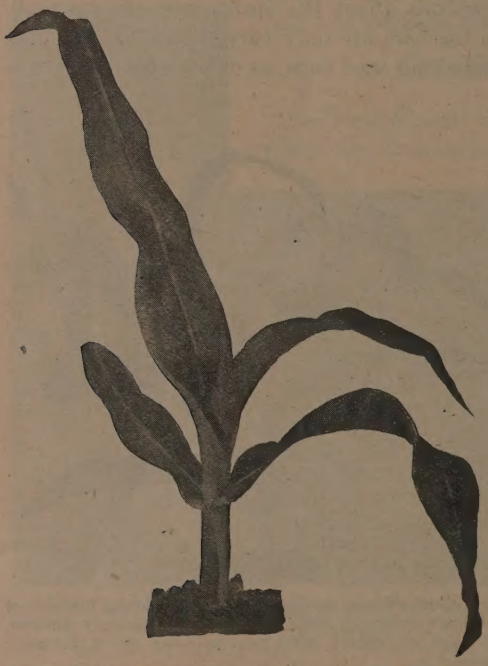

FIG. 3.—Healthy corn seedling, the same age and on the same scale as the dead and diseased ones in figure 2.

Various symptoms may develop as a result of this early injury. The diseased kernels, roots, and lower parts of stalks become rotted and dark colored (fig. 1). The seedlings which are badly infected die very soon after germination (fig. 2, *A*, *B*). This manifestation of the disease is known as seedling blight and is the cause of poor stands in many fields.

Other seedlings which are only slightly affected often partly recover under favorable conditions for growth by pushing out new roots above the affected parts. Such plants may show considerable yellowing and remain stunted. They are handicapped during their early growth, and will not be so productive as those which are not affected. In some cases, the recovery from the seedling infection is so slow that the plants make very little progress during the entire growing season and produce low yields (fig. 2, *C*). The contrasted appearance of a normal corn seedling is shown in figure 3.

SYMPTOMS IN THE YOUNG-PLANT STAGE.

When the corn is about knee high, or a little higher, diseased fields usually show characteristics similar to fields on poor soils. Where low fertility or poor physical condition of the soil and the disease occur together the diseased condition is more severe. In diseased fields there usually is marked irregularity in the height of the plants (fig. 4). The diseased plants are stunted to varying degrees and frequently are spindling and off color. The lower leaves commonly show considerable dying at the tips. The inside

FIG. 4.—Field of corn showing diseased row at left. Note the lower growth, dwarfed plants, and missing hills, as contrasted with the healthy rows at right.

of the base of the stalk usually is discolored and more or less rotted. The early roots may be considerably rotted. New roots may be developed, but they push out rather high up.

Plants affected in any of these ways do not withstand poor growing conditions well. Healthy plants in the same or surrounding fields grow faster and their normal dark-green color is in rather sharp contrast sometimes to the lighter green of diseased plants. On hot days in dry weather the diseased plants show a tendency to wilt considerably before the normal plants do (fig. 5).

SYMPTOMS IN THE SILK-AND-TASSEL STAGE.

The diseased plants usually are so delayed in their growth that they do not come into silk and tassel until 5 or 10 days later than the normal plants (fig. 6). As a result, the ears on some diseased stalks may be only partly or not at all pollinated. At this stage some of the diseased stalks may show good color, but some of them may show dying of the tops, including the tassel. The lower leaves also may be fired. Considerable leaning of stalks (fig. 7) may occur at this time, due to the weakened condition of the roots (fig. 8). This becomes more marked later in the season.

SYMPTOMS SHOWN IN THE EAR STAGE.

On healthy plants the ears ripen normally while the stalks and most of the leaves are still green (fig. 9, *A*). At this stage the diseased plants may be either prematurely dead (fig. 9, *B*) or unduly delayed in ripening. Some of these late-maturing stalks may be barren; others may bear ears of various sizes and qualities, ranging from worthless nubbins to full-sized ears. All such ears are somewhat delayed in ripening. Many diseased stalks will be either leaning or blown down (fig. 10). This results from the weakened root systems and from the rotting of the stalks themselves.

FIG. 5.—Diseased corn plant wilting during hot weather.

Many ear shanks on diseased stalks are broken (fig. 11) as a result of rotting. In some cases these ear-shank symptoms also occur on stalks that are otherwise healthy, when infection takes place in the ear shanks or at the butts of ears. Any ear that hangs down on a broken or rotten shank, therefore, is under suspicion, even though it looks fairly good. In some cases the whole ear is rotted or soggy. In other cases it may ripen, but with kernels unnaturally rough, shrunken, or starchy, or rather dull in color.

The results of extensive experiments indicate that the best ears are those that ripen early on good, normal, upright stalks and that remain green while the husks turn yellow to brown and the ears become firm. The best ears usually are not borne perfectly erect, nor do they hang straight down. They are borne on unbroken,

unrotted shanks and show no indications of rotting of the kernels, The kernels of such ears are firm, with dents rather shallow and smooth, and having a bright color.

CONTROL MEASURES.

The best method for the control of these diseases that has been developed to date is to select disease-free seed ears. Diseased ears or even apparently healthy ears from diseased stalks should not be selected for seed. The proper selection of seed corn is no single operation that can be completed within a few days. The different steps that are necessary to obtain the best results are discussed in their order in the paragraphs that follow.

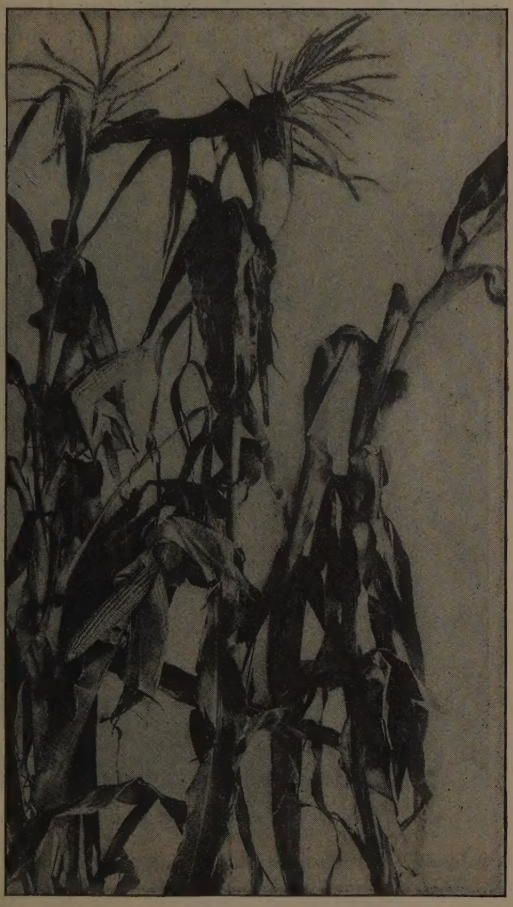

FIG. 6.—Three corn plants of the same age: Normal plant (center) with ears well developed and kernels in dough stage; diseased plants (on either side), the one at the left in the milk stage, the one at the right with silks just out.

FIELD SELECTION.

SELECT SEED EARS BEFORE FROST.

Field selections of ears of seed corn should be made before the first killing frost. This makes it possible to distinguish between ears that have matured normally (see fig. 9, *A*) and those that have ripened prematurely on account of disease (see fig. 9, *B*). After the first killing frost the stalks and especially the shanks and the ears are invaded rapidly by these disease organisms. Warm weather following the first killing frost favors these ear infections, which greatly reduce the vitality of the seed.

SELECT THE BEST NORMALLY MATURED EARS.

Fully matured ears with sound shanks from upright, sturdy stalks have shown, on the average, greater vigor and considerably more resistance to these rot diseases than similar appearing ears from stalks either slightly or badly diseased. Moreover, ears from leaning and broken stalks and ears with slightly rotted shanks from erect stalks are likely to be diseased. Stalks that are wilted and prematurely dead commonly bear diseased ears which are frequently mistaken for early-maturing ones by those not suspecting their

FIG. 7.—Rows of corn, showing healthy plants erect and diseased plants leaning, due to rotted root systems.

diseased condition. Many apparently desirable seed ears droop because of weak, rotten, or broken shanks. Such ears are often diseased. Ears from stalks and shanks showing these symptoms have given greatly reduced yields when planted in experimental plats.

SELECT EARS FROM THE BEST NORMAL STALKS.

As susceptibility to one disease often means susceptibility to other diseases, it is well to avoid ears from smutted or badly rusted stalks. Furthermore, ears from stalks with either rolled, crinkled,

or spotted leaves, or from plants with many fired leaves, also yield less and should not be selected for seed.

QUANTITY OF SEED EARS TO SELECT.

In order to have enough seed ears from which to get the best seed, it is advisable to gather about five times as many as will be required for next year's planting. This will allow for shrinkage, discarded ears, butt-and-tip shelling, grading, etc.

SUMMARY OF RECOMMENDATIONS FOR FIELD SELECTION.

It is best to take only matured ears of medium size from upright plants whose stalks and portions of the leaves are still green and whose ears are supported at a convenient height on strong, sound shanks. (See fig. 9, *A*.)

CURING AND STORAGE.

The seed ears, after being selected in the field, should be so handled and stored that they will dry uniformly and thoroughly. If the moisture content of the ears remains high, harmful organisms may grow into the ears and infect them. Because of this it is of the utmost importance that the ears be kept in a dry, well-ventilated place. See Farmers' Bulletin 1175 for full directions on curing and storing seed corn.

SUBSEQUENT SORTING OF THE SEED EARS.

After the seed ears have been selected, cured, and stored they should be very carefully sorted during the winter or early spring. Only the very best ears should be retained for seed.

FIG. 8.—Root systems of two corn plants, the one at the left healthy and the one at the right diseased, showing weakened condition.

DISCARD OVERSTARCHY EARS AND THOSE THAT ARE TOO ROUGH.

The effects of the rot disease as shown on the roots and stalks are often not severe enough to prevent the development of ears of normal size, but may result in the production of ears that are im-

perfectly matured. The kernels of such ears are more or less starchy and usually have a rougher denting (fig. 12, *B*) in dent corn than fully matured ears (fig. 12, *A*) selected from healthy plants. In many places experimenters and farmers actually have preferred these rougher and more starchy ears for seed. Frequently such ears are diseased. Plantings from such starchy, immature seed ears have been compared in field experiments with plantings from mature, disease-free seed ears. In the crop from the starchy ears there were more diseased plants, and the acre yield often was as much as 15 bushels less. Ears with very starchy kernels should be eliminated from the seed stock before making germination tests. This is advisable because immature and starchy kernels absorb water more rapidly during germination than the better matured and more horny kernels, and hence the poorer kernels sometimes appear to have a stronger germination than the good ones. This is especially true when the germination test is read too soon.

FIG. 9.—Healthy and diseased corn plants, showing differences: *A*, Healthy, with leaves and stalk green and ear ripe and in normal position; *B*, diseased, with leaves and stalk dead and ear prematurely ripe and hanging from a rotted, broken ear shank.

DISCARD EARS THAT SHOW ANY EXTERNAL EVIDENCE OF DISEASE.

Most ears having shank attachments pink, slightly pink, or brown colored, or cracked (fig. 13), or shredded (fig. 14) have grown on stalks more or less diseased. Such ears usually are diseased and should be discarded without further examination, regardless of their

good appearance. Ears with tips that have been exposed to the weather before the ears were harvested very frequently are infected at the tip end by organisms washed in from the outside. When the kernels are dull in appearance, slightly brown on the germ side, or somewhat moldy where they have been attached to the cob, it is very likely that the ears are diseased. Discard any such ears before making the germination test.

SELECT THE BEST EARS.

As the result of experiments conducted for a number of years it has been found that the best ears have a bright, shining appearance, indicating complete maturity. The shank attachments are clean and free from any discoloration when freshly cut (see fig. 13, upper

FIG. 10.—Row of corn grown from diseased seed, showing all stalks broken down. Compare adjacent healthy erect rows.

ear). The denting of such ears of dent varieties practically always is shallow to smooth. The kernels are thick and plump, bright and clean in appearance, and have a horny endosperm. The germs are good sized and well developed. When the seed has been carefully selected in the field at the right time and properly stored, it is possible to eliminate a large percentage of the diseased ears and those susceptible to disease by applying these physical methods in the subsequent sorting.

GERMINATOR SELECTION.

The germination test, when conducted carefully and interpreted properly, is a very valuable further aid in the selection of the very best seed ears. By its use, most of the diseased and weak ears which

FIG. 11.—Two ears of corn on rotted, broken ear shanks. Note that one ear looks good enough for seed, but it really is badly diseased.

are not eliminated by physical selections can be detected. A seed stock may be secured thereby that is unusually strong and practically free from disease.

Two methods of testing seed corn are in use. In the first, a table germinator with a limestone-sawdust base is used. In the second method, modified rag dolls are used.

TABLE GERMINATOR.

The table type of germinator is shown in figure 15 and on the title page. It consists of a framework supporting a wire screen on which a 2-inch layer of saw-

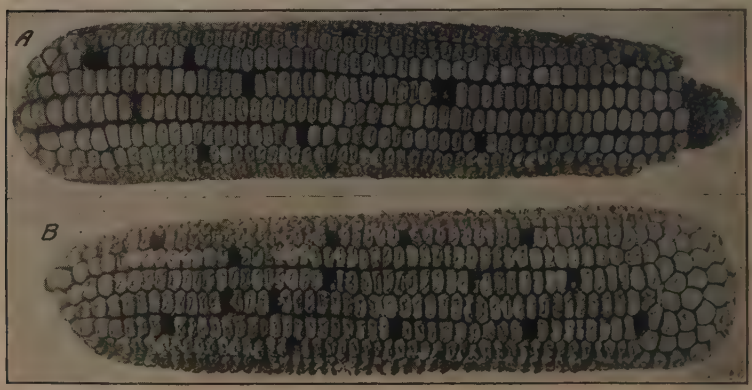

FIG. 12.—Healthy and diseased ears of corn: *A*, Well-matured ear with bright, rather smooth, horny kernels; *B*, diseased ear with dull, rough, starchy kernels.

dust is placed and covered with a layer of agricultural limestone one-fourth of an inch or more in thickness. Limestone protects the germinating seedlings from the effects of the injurious substances which develop in wet sawdust. A sheet of heavy muslin cloth is spread over the limestone and water is sprinkled on the cloth in sufficient quantities to moisten thoroughly all the sawdust. If the sawdust is new, it should be watered frequently for two days before starting the germination test.

FIG. 13.—Butts of three ears of corn, all of good appearance, but the lower ones showing cracked and discolored shank attachments.

Numbers may be painted on the side of the framework at intervals of 10 or 12 inches (see fig. 15), to divide the germination table into blocks by the use of which a record may be kept of the position of kernels from the ears tested. The ears tested in each block may be placed on a near-by rack or in a crate in the same order in which they were placed on the germinator. Ten kernels usually are taken from each ear. They are so arranged on the cloth that each kernel will be at least an inch from any other kernel, and no kernel should be less than 2 to 3 inches from the edge of the germinator. The results may be observed more easily and more accurately when the kernels are placed with the germ sides up and the tips all pointing in the same direction.

After the kernels have been arranged on the tables, they are covered with a sheet of heavy muslin. To prevent rapid drying of the germinator, the cloths are covered with a piece of burlap of the same size, made from medium-heavy gunny sacks. Any other heavy cloth may be used if burlap is not available. When the seedlings on the germinator have sprouts an inch or more in length, the heavier cloths may be removed and the seedlings covered with damp muslin only. Clean, warm water

should be sprinkled on the cloths twice a day in sufficient quantities to keep the cloths moist. It is especially desirable to have sufficient moisture at the beginning of the test and to avoid any drying out later. The germinator should be placed in a room where a temperature of 75° to 90° F. and a high humidity can be maintained.

The test is completed and the results recorded when the seedlings have grown to a height of 4 or 5 inches, which requires at least seven days where the temperature averages 85° to 88° F. Where the average temperature is a little lower, that is, from 75° to 80° F., 10 or 12 days may be necessary for the seedlings to reach the desired height.

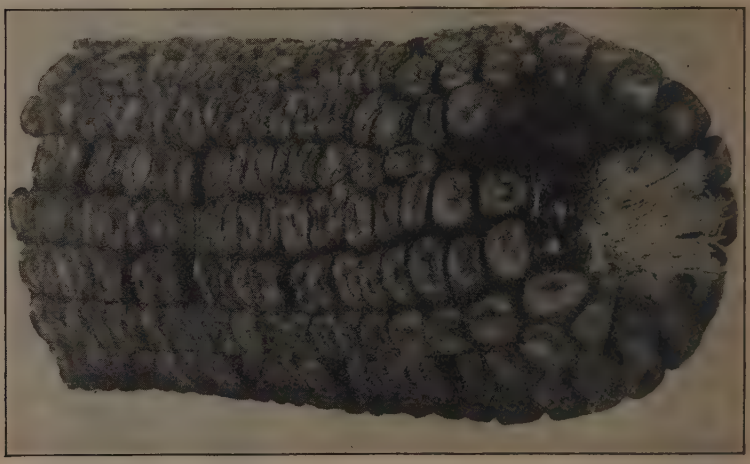

FIG. 14.—Ear of corn showing shredded shank attachment and also somewhat starchy kernels.

Before new cloths are used on the germinator they must be placed in boiling water for at least 15 or 20 minutes, after which they should be rinsed thoroughly. This boiling and rinsing must be repeated before each germination test.

MODIFIED RAG-DOLL GERMINATOR.

The rag-doll germinator has been modified so that diseased kernels can be detected by using it. This method is illustrated in figures 16 and 17. The modified rag doll consists of a muslin cloth 12 by 54 inches long, which has been boiled in water, as indicated for table germinator cloths, and placed on a strip of firm, water-finish fiber paper of equal width and slightly longer (fig. 16).

The kernels from each ear are placed in a row with the germ sides down and with the tips all pointing toward what will be the lower end of the rag doll when it is placed in the germinator box. The cloth is thoroughly wet and then the paper, cloth, and kernels are

carefully rolled up. Rubber bands are placed around each end of the rag doll. The upper end of the rag doll is indicated by attaching a tag bearing the numbers of the ears used and the date of the test.

FIG. 15.—Table germinators, one open, the others covered, in the warehouse where many of the seed-corn germination experiments were conducted.

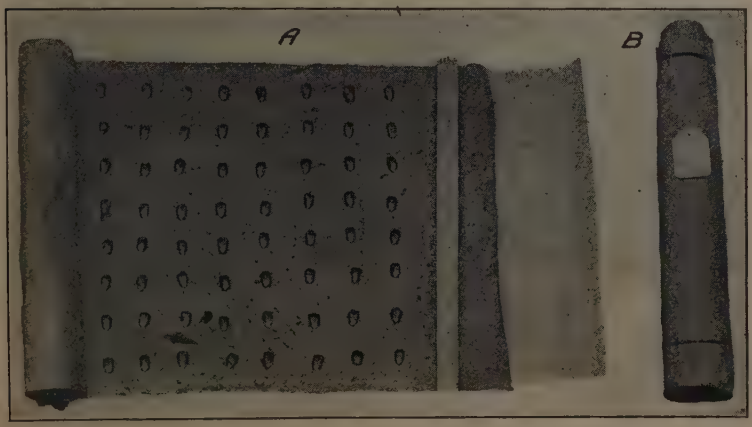

FIG. 16.—Improved rag-doll germinator: *A*, Open, showing insulating paper, cloth, and corn kernels in position; *B*, rolled and labeled.

The rag-doll germinators are placed in a box receptacle, as shown in figure 17. This receptacle consists of an outer and an inner box,

with sawdust between them. The inside box may be of any convenient size, but should be at least 18 inches deep. Wire cross rods should be spaced at least 3 inches apart in the upper part of the inner box.

FIG. 17.—Modified rag-doll seed germinators, showing double box with rag dolls in position.

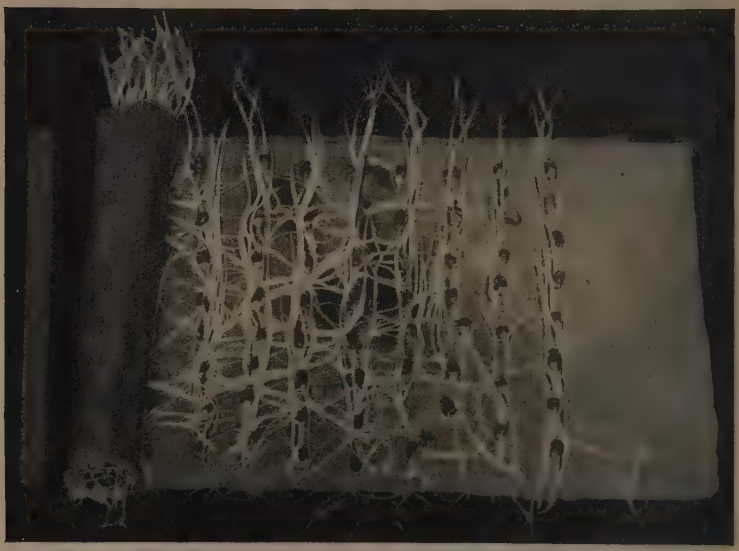

FIG. 18.—Rag-doll germinator unrolled for the reading of results.

The sawdust layer should be at least 2 inches thick between the boxes. When in use the sawdust is kept thoroughly wet and the rag dolls are sprinkled twice daily. The top of the germinator box is kept covered with wet gunny sacks. The box should be kept at a temperature of 75° to 85° F. Where electric current is available this has been satisfactorily accomplished by using electric bulbs under the boxes.

READING THE GERMINATION TEST.

At the end of seven days the rag dolls are ready for readings. They are removed from the germinator box and unrolled (fig. 18). The appearance of apparently healthy and diseased rows of seedlings in the modified rag doll is illustrated in figure 19.

Those seedlings which are rotted, as shown in figures 19 and 20, indicate the ears that are to be discarded. Great care is necessary in reading results on the germinator. Some seedlings which appear healthy grow from kernels rotted on the inside (fig. 21). The only safe practice is to cut open lengthwise all kernels not evidently rotted. (Compare figs. 21 and 22.) Ears represented by seedlings with weak and slender sprouts or short and slender feeder roots (fig. 23) are undesirable for seed and should be thrown out along with those ears represented by rotted seedlings.

The best seed ears of a well-bred strain of corn will produce sprouts like those illustrated in figures 22 and 24. Such seedlings (fig. 24) have thick, sturdy sprouts, an abundance of thick, healthy roots, and show no evidence of rotting when cut open (see fig. 22). The kernels from the best fully matured ears usually remain free from molds, even when the corn has remained on the germinator longer than seven or eight days at a temperature of 85° to 88° F. Those ears should be selected for seed which are represented on the germinator by kernels that all germinate and all show clean, vigorous seedlings, without rotting, like those shown in figures 22 and 24.

FIG. 19.—Corn seedlings from two diseased ears (right) contrasted with seedlings from a disease-free ear (left). Note the dark areas on the diseased seedlings, showing where the mold is rotting them. The kernels from each ear are laid in a single row in a vertical position, which tends to prevent the lateral spreading of the molds to adjacent rows.

SHELLING AND GRADING.

There is considerable advantage in shelling seed ears by hand. Occasionally, ears that have appeared good in all recommended

examinations up to this time may finally prove to have starchy kernels (fig. 25) or some badly diseased spots when shelled. By shelling each ear separately into a small pan, the ears having starchy, moldy, discolored, or otherwise suspicious-looking kernels which had not been detected prior to this time may be discarded. There is no cracking or chipping of the kernels when the ears are shelled by hand. This is a distinct advantage when the very best seed is desired.

The best seed corn can not be considered ready for planting until it is properly graded. Careful grading insures a more uniform drop when the proper plates are used in the planter, and this is very essential where an attempt is being made to obtain a uniform stand of vigorous, healthy plants.

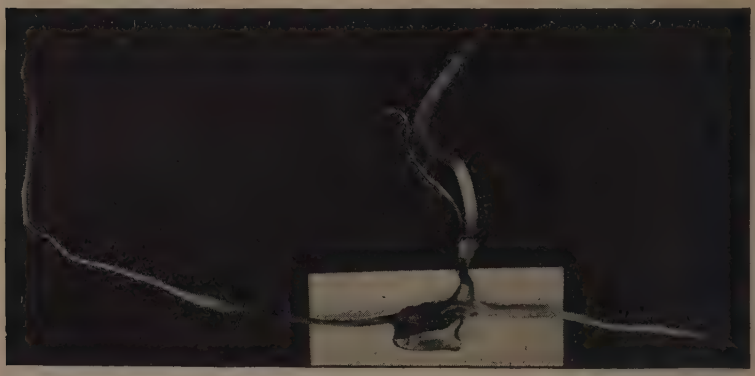

FIG. 20.—Corn seedling severely infected, nearly dead.

BREEDING.

Experimental results indicate that varieties and strains of corn differ widely in their susceptibility and resistance to the rot diseases of roots and stalks. Some strains, derived from the best varieties commonly grown in the corn belt, have shown considerable resistance to these diseases in experimental plats. However, until varieties with greater resistance can be developed, considerable progress in producing higher yields more economically can be made by the selection of the very best seed from the best varieties now available. The continued selection of seed according to the foregoing recommendations has been very effective in improving strains from different varieties.

SOIL RELATIONS.

Intensive investigations have been undertaken recently to determine the influence of different methods of soil management, various soil treatments, and various crop rotations represented in the corn belt on the development of these various rots of corn. The experiments have not been in progress long enough to justify recommenda-

tions for farm practice. However, it is evident that losses caused by these corn diseases are much greater where there is more than 50 per cent of corn in a 4-year rotation. In fields that have been

FIG. 21.—Rotted corn kernel discovered only by cutting. The seedling was apparently healthy except for the small number of roots.

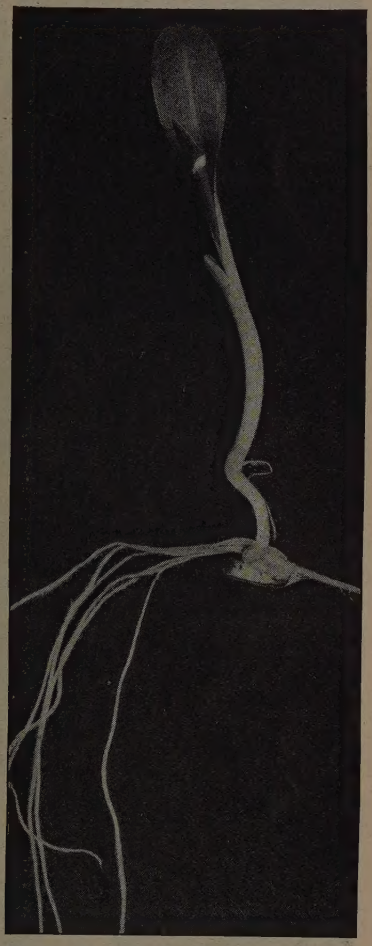

FIG. 22.—Healthy corn seedling produced from a healthy kernel, shown by cutting. Note the numerous strong roots.

cropped to corn continuously for five or more years, it has been almost impossible to find enough plants sufficiently free from disease to permit the selection of desirable ears for seed.

Acid soil reaction, improper physical condition of the soil, lack of essential plant-food materials, and poor drainage are some of the soil

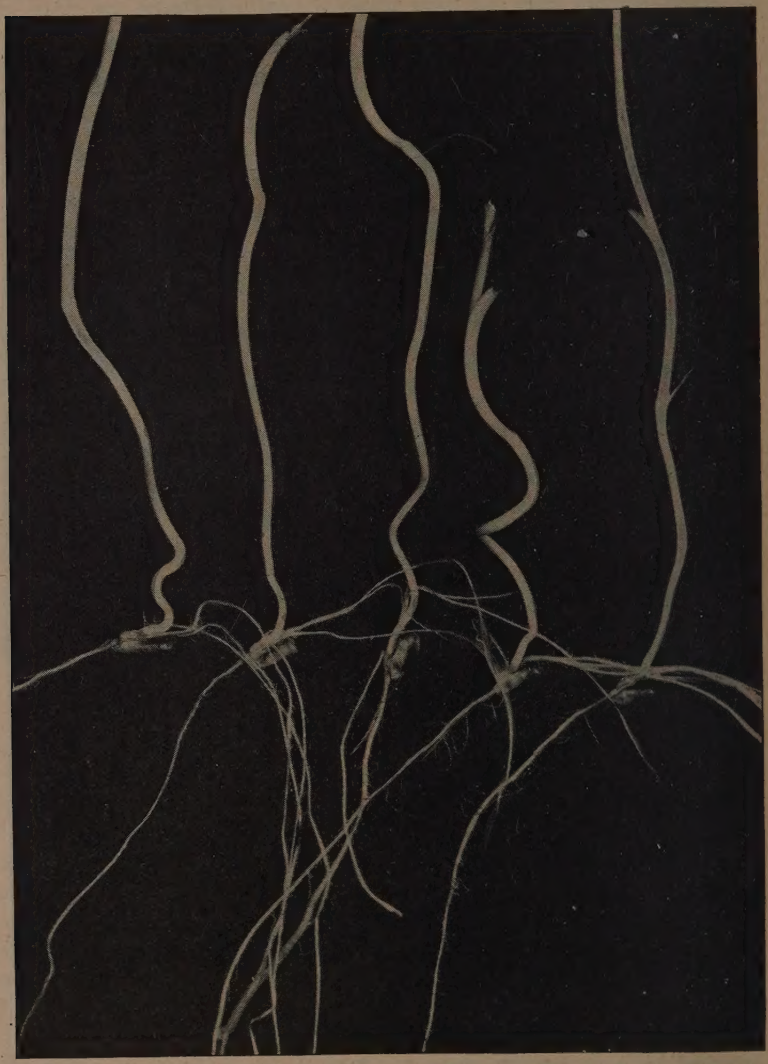

FIG. 23.—Corn seedlings with weak, slender sprouts and roots; not necessarily diseased, but such seed is undesirable because it is susceptible to disease.

factors favoring the development of the corn rots. The correction of soil troubles and the adoption of some approved rotation are very es-

sential steps in reducing losses due to these diseases. However, the occurrence of these diseases is not limited to soils that are faulty in any way. They occur on the very best corn soils. In any case, it is profitable to plant seed as nearly free from disease as possible.

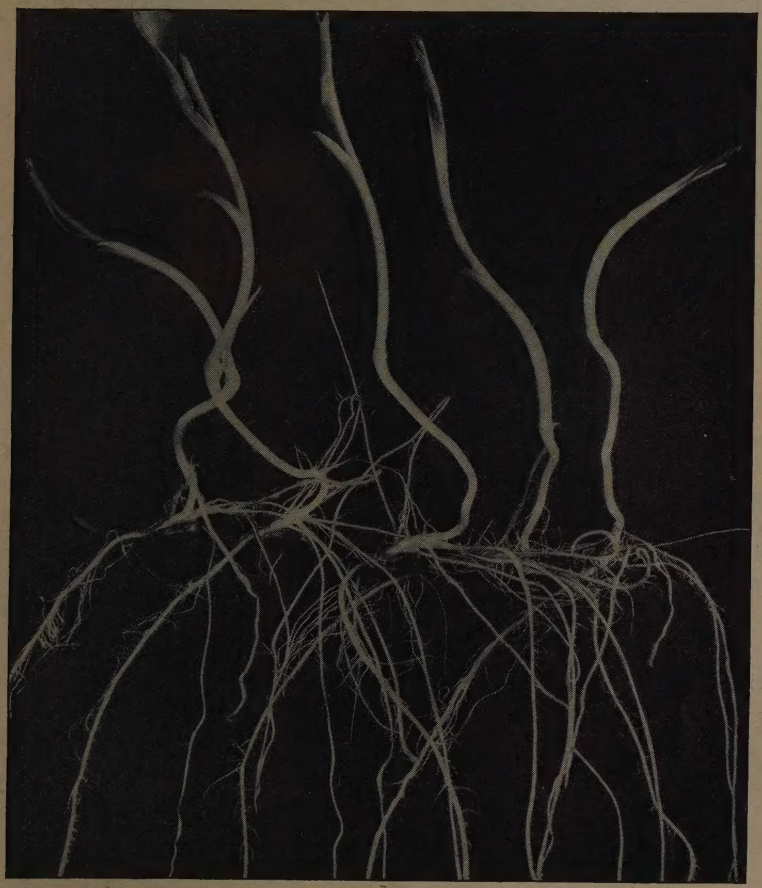

FIG. 24.—Healthy corn seedlings, showing strong vigorous sprouts with numerous strong roots.

CONCLUSIONS.

Seed selected and prepared according to the foregoing recommendations, when planted in competition with average seed, has given better stands, a large percentage of strong, healthy plants, fewer leaning, down, and broken stalks at harvest, and increased yields ranging

from 5 to 30 per cent. Plants from such seed practically always have endured without injury unfavorable weather conditions following planting at the beginning of the normal corn-planting season.

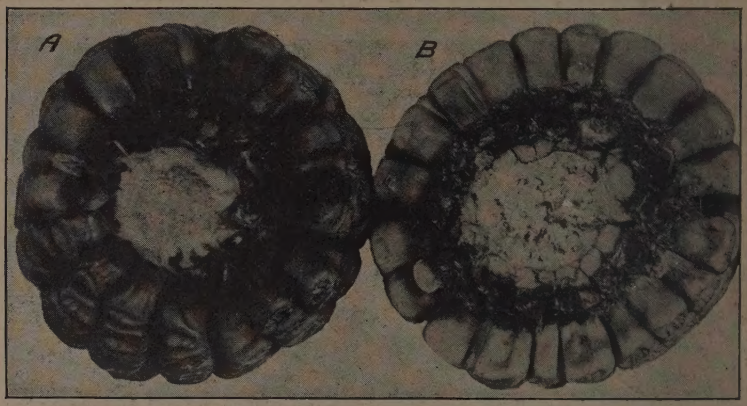

FIG. 25.—Two apparently good seed ears of corn, one of which (*B*) is found to have starchy kernels when shelled.

Under similar unfavorable conditions seed ordinarily considered good often has either been a failure or produced an unprofitable crop. Experiments carried on during the past three years have shown that it is possible to increase yields from 10 to 15 bushels per acre by the methods recommended in this bulletin.